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INVESTIGATION OF THE 2D FREE TURBULENT JET

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The study aimed to verify the properties of two-dimensional, turbulent, free jet on the basis of the results of experimental measurements, theoretical calculations, and CFD simulations conducted with the use of Flovent computational program.

The laboratory examinations took place at University of Warmia and Mazury in Olsztyn in a special test chamber with dimensions 3850x2255x2009 mm. Plexiglas enclosure limited the influence of external conditions. The Witoszynski's nozzle of dimensions: h=0.6 m and width b=0.02 m was used to generate a 2D air stream at the output. The velocity range used during the investigation was about 8 m/s to 28 m/s, so the Reynolds number based on the nozzle's width was in the range Re= 10000 up to almost 38000. Tests were made for six runs. With the help of thermoanemometry technique the measurement of velocity profiles and turbulence level was performed in different sections along the stream axis, [1].

Assuming the constant eddy viscosity ε across the stream Gortler, [2], gave the theoretical velocity distribution (1) with some constant value σ and J as the momentum per unit width of slot. Mean velocity u parallel to the jet axis is consistent with the model:

$$u = u_m \sec h^2 \frac{0.88y}{y_{m/2}} = \left\{ \frac{3J\sigma}{4\rho x} \right\}^{\frac{1}{2}} \sec h^2 \frac{\sigma y}{x} \tag{1}$$

where u_m is a maximum value of u at a given station along x and $y_{m/2}$ is a value of y, where $u = \frac{1}{2} u_m$.

Also, the spreading rate and the location of virtual origin of the free stream was the subject of many investigations, where the formula (2) with two constant K_1 and K_2 is usually used [3]:

$$\frac{y_{m/2}}{b} = K_1 \left(\frac{x}{b} + K_2 \right) \tag{2}$$

The FloVent code, from Mentor Graphics company, was used for CFD simulations. All the laboratory examinations were repeated. In a numerical model the total number of grid cells was about 500000. In the initial area, where the stream parameters were analyzed, the grid was thickened and had dimensions of a single cell X = 5 mm, Y = 20mm, Z = 30mm (directions marked in accordance with the scheme adopted in the Flovent). The area has dimensions X = 1.20m, y = 0.62m, Z = 1.00m. The rest of the bench, the cell dimensions do not exceed 75mm in all directions. Simulations were done with turbulence K-Epsilon model.

The results obtained by CFD, the theoretical distribution according to eq. (1) and experiment are compared with each other in Fig.1 for Re=27685 the distance from nozzle x=0.50 m.

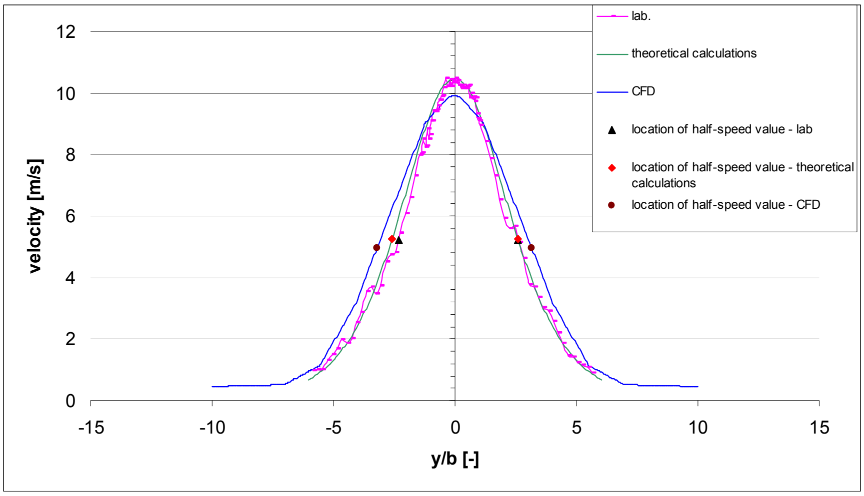

Fig. 1: Air velocity distribution, Re= 27685, distance from the nozzle is x=0,50m.

Additionally, the spreading rate and the virtual location of the stream origin was investigated and the results for the spreading rate are presented in Fig. 2, and eq. (3) described the spreading rate in our case, which is not linear, and a little bit different than in [3].

$$\frac{y_{m/2}}{b} = 0{,}4317 + 0{,}0489\frac{x}{b} + 0{,}0021\left(\frac{x}{b}\right)^2 + 0{,}00002\left(\frac{x}{b}\right)^3 \tag{3}$$

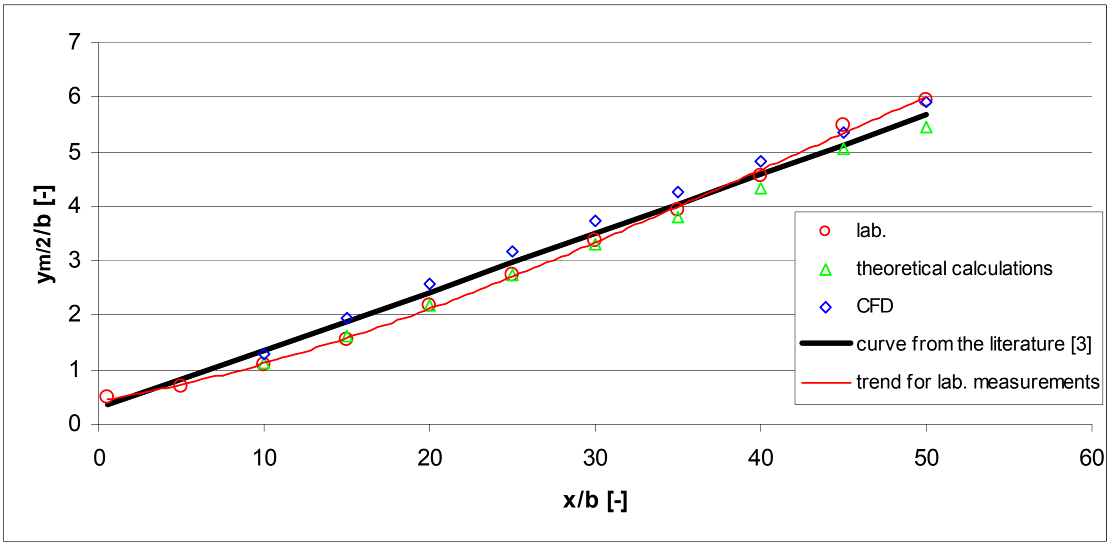

Fig. 2 The spreading rate of the free stream

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